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(54) Title: WIDE AREA NETWORK BASED OBJECT SENSOR SYSTEM

(57) Abstract: A wide area computer network provides monitoring of multiple sensor systems located at remote locations. Specifically, a telemetry data from sensors at various locations is received at a central database which is accessible via the Internet by local personal computers. A store manager is thus able to display in real time at a distant location the temperature status of various refrigeration units located at various stores. The central database provides access to customer data only to authorized users. In this way, a single internet interface is provided to receive and manage data from multiple customer accounts over a common system. Further, the system provides separate accurate financial billings to customers based on number or times of access or other customer specified arrangements. In addition, the central database is flexible to receive data from various installations including from dedicated sites or from mobile locations. In this way, telemetry data may be tracked and displayed throughout a multi-stage process involving multiple parties. Alert notifications may be sent to any authorized person in the process chain of out of limit operation.

APPLICATION FOR PATENT

INVENTOR: ALAN C. HELLER

TITLE: WIDE AREA NETWORK BASED OBJECT SENSOR SYSTEM

SPECIFICATION

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

Not applicable.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to identification, location, and telemetry systems, and more particularly, to the ability to track identification, location and telemetry information remotely and interactively from a web page on the internet.

2. Description of the Related Art

Identification, location, and tracking systems identify the presence, the absence or movement of unique device affixed to people and objects within a predefined area. These systems find increasing application in all areas of automation, accounting, manufacturing, and materials handling areas as well as medical facilities and other areas where real time location can be critical.

In a typical system, one or more objects or individuals are provided with transmitting devices, commonly known as "TAGs," which interact with an array of receivers in a given tracking area. These systems have employed wireless transmission technology such as radio frequency or ultrasonic based transmitters and sensors. A system using RF tracking methods is disclosed in U.S. Patent No. 5,119,104, entitled LOCATION SYSTEM ADAPTED FOR USE IN MULTIPATH ENVIRONMENTS, which is hereby incorporated by reference.

In addition, the remote transmitting systems have been concerned to a great degree with power conservation. To this end, a method has been developed for incorporating a plurality of receivers and time of arrival data to accurately identify telemetry information while at the same time maximizing power conservation. A telemetry system using strobe signals at predetermined intervals is disclosed in U.S. Patent Application No. 09/027,968, entitled LOCATION,

IDENTIFICATION AND TELEMETRY SYSTEM USING STROBED SIGNALS AT PREDEFINED INTERVALS, which is hereby incorporated by reference. This system reduces the transmitter power consumption by transmitting only a portion of a sensor identification in any one burst.

As computer use has become a fundamental part of so many people's lives, interconnectivity between computers has taken on new proportions. Today, WANs, or wide-area networks, which may interconnect thousands of computers spanning diverse geographical areas, are common place. The explosive growth of the internet in the last decade has eliminated geographical barriers to create a "virtual global village."

SUMMARY OF THE INVENTION

A system according to the present invention provides a network sensing system to monitor telemetry data from various remote locations. Remote access to a database manager is provided via the Internet. A number of remote wireless sensor systems located at various customer locations send wireless telemetry data to local reading devices, such as food temperature data. A unique transmission protocol is used minimizing required transmission power thereby increasing battery life for the miniature sensors. Sensors are installed easily in numerous configurations, such as grocery stores, food distribution stores and food processing plants, because of the wireless nature and long battery life. In addition, each sensor is uniquely identified by the system to provide accurate telemetry interpretation.

Sensor data is then transmitted from the reader to the data manager over an Internet connection using software controlled protocol. The software can easily be reconfigured for various telemetry applications. The data manager is then configured to receive and display in proper format any number of data types, including food temperature, humidity, power and security messages.

The data manager is centrally accessible to multiple customers to provide secure access to authorized requests. In this way, grocery store operators monitor various temperature critical store operations. Likewise, each unique sensor is easily associated with a specific food parcel to track the cold chain history, as well as real time monitoring, of the food product during the various stages in food production, processing, delivery and retail. In this way, the data manager is able to accurately attribute liability for certain environmental failures based on when, and under whose control, the failure occurred.

The data manager is easily configured to provide notifications to identified individuals for certain environmental conditions, for example, out of range temperature operation. In

addition, the data manager provides reliable and flexible financial billing capabilities among the various customers based on that customer's involvement in the process. The wide are network thus provides a single web based interface capable of tracking telemetry data from multiple independent systems and accurately allocating financial billing responsibilities among the various responsible parties in each given system

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention can be obtained when the following detailed description of the preferred embodiment is considered in conjunction with the following drawings, in which:

Figure 1A is a block diagram of a local sensor system according to the disclosed subject matter;

Figure 1B is a more detailed block diagram of a sensor system incorporating multiple local systems of Figure 1A;

Figure 2 is a chart providing examples of actual transmissions between the communicating devices of Figures 1A and 1B;

Figures 3A-3E are screen shots of a graphical user interface displaying information from the sensor systems of Figures 1A and 1B;

Figure 4 is a diagram showing a telemetry tracking system for transportation applications; and

Figure 5 is a diagram illustrating a system for tracking telemetry data throughout an entire cold chain food product distribution system.

DETAILED DESCRIPTION OF INVENTION

U.S. patent application, attorney docket number H053743.0015US0, entitled, "Cold Chain Food Safety Management", commonly assigned and concurrently filed is hereby incorporated by reference in its entirety.

Turning to Figure 1A, shown is a high level illustration of a system providing Internet access to remotely gathered sensor telemetry data. The Internet based automatic data collection system 10 arrays wireless sensors with small antenna and reader devices interconnecting to an Internet linked personal computer. The system provides for automatic data collection and distribution to multiple media. Data can conveniently be monitored remotely through any Internet connected computer or periodic notifications generated over telephone, cellular phone, pager or facsimile.

Sensor array 50 may be comprised of any number of sensors for measuring various telemetry data. Sensor array 50 uses a unique transmission protocol such as the protocol disclosed in U.S. Patent Application No. 09/027,968, previously incorporated by reference. The unique transmission protocol permits increased sensor identification making each sensor unique and fully Internet addressable. The sensors of the sensor array 50 are small wireless sensors which allow for convenient and timely installation in any number of configurations. The reader device 52 accepts temperature and identification as well as other telemetry data from the sensors of the sensor array 50. The reader device 52 then relays the information to a dedicated PC 56, for example. According to one embodiment, software can be provided on the PC to allow for data viewing into a local log file. In addition, the data from the reader is sent via the PC 56 or across a bridge device over the Internet 58 to a data management service discussed in more detail in connection with Figure 1B. Additionally, various advisory functions can be utilized based on predefined thresholds for the telemetry data. One such example includes providing pager notification from interface device 54 triggered from telemetry data from the reader 52. The paging function may be alternatively or in combination performed at the local computer site or at the internet side.

The wide area network system 10 is flexible to provide a number of varied applications. For example, in fixed locations such as cold storage facilities, these wireless devices provide data collection flexibility. For shipping or trucking applications, for example, the flexible system 10 allows continuous yard management and driver alerts when away from the trucking yard. Such a mobile application is discussed in more detail in connection with Figure 3 and Figure 4. In a supermarket management environment, the system 10 provides manager access to real time temperature data for temperature critical and other environment critical products and equipment. Complete tracking is further provided across each stage in a process, such a food distribution, through seamless transitions at each of a multiple stage process. Further, among each of these customer locations and processes, the system 10 provides accurate attribution of liability for failures, such as "too hot" operation, based on when, and under which party's control, the failure occurred. Such tracking may be provided either as historical data or on a real-time monitored based. Other environmental factors, in addition to temperature, can be monitored as well, including humidity, presence in security (such as door open/close), ripening gases and load monitoring or power management data.

Turning now to Figure 1B, shown is a detailed illustration of a wide area network (WAN) system 100 providing remote access to information gathered from multiple locations according to an embodiment of the disclosed subject matter. Each set-up provides customer access from

multiple remote locations to data collected from sensor systems at the multiple locations under control of that particular customer. For example, customer A 102 through a local computer 104 is provided convenient access to information gathered at customer A's remote locations 120 and 122. Likewise, customer B 152 can locally view information obtained from its sensor system 150 at the same customer B location 124. Essentially, a customer is able to view telemetry data gathered at various locations through simple access to the Internet. According to an embodiment, each customer is provided secure access such that only authorized users can view a particular set of data, i.e., telemetry data gathered at a specific location.

Additionally, multiple levels of secured access can be provided on per customer basis. For example, with reference to a grocery store application, a regional food store chain manager may require access to operations at the various store locations within the region, while a local manager may be restricted to access only to that manager's store of responsibility. Likewise, different security levels can be established across operators at each of various stages in a multi-stage process, such as the food distribution network of Figure 4. The security measures can be implemented according to any number of well-known protocols, such as unique passwords and the like.

The WAN system 100 can be set up in a variety of ways to provide flexibility with any numerous configurations. For example, customer A can view information from multiple remote locations through any computer not necessarily at the location where the telemetry information is gathered. All that is needed is a personal computer, for example, having access to the Internet and any common Internet browser. Each customer is given a security authorization code such that only information regarding that customer's locations or sensor systems are authorized for viewing. Additionally, customer B can wish to view information gathered from its sensor system 150 through a local computer 152 housed at the customer B location 124. The local computers 56, 104 and 154 may be of a typical PC form or of a reduced functionality embedded controller.

Essentially, a data collection and management system is provided at data manager 160 whereby information gathered at the various locations is received and sorted according to individual customer accounts. Thereafter, customers can access their respective information banks by providing a unique authorization code. As such, customer A is allowed to view information gathered at the customer A locations 120 and 122 but not other customer information, for example, information gathered from customer B location 124. As discussed above, additional levels of security access can be provided within each customer account.

The wide area network system 100 is additionally, configured to provide accurate financial billing among the various independent customer accounts. In this way, each customer

is able to request various custom services, including different sensor configurations and data management features and then billed accordingly, based on that customers use of the system 10. Further, flexible billing is provided to each customer whereby separate billing is automatically generated for each entity under that customer's control. For example, a large food store chain manager may request that each of its multiple stores be individually billed to maintain certain accounting protocols. The data manager 160 is thus capable of determining which of the individual stores are accessing the database, which sensors at which location are active, which locations have received specialized notifications, etc. and bill accordingly on such a location by location basis. It should be understood that the reliable tracking ability across multiple locations allows that many other billing protocols may be established. However, it is worth noting that the system 100 uniquely combines this billing flexibility with its single Internet telemetry collection and retrieval interface common to all customers.

The data manager 160 is designed to provide maximum flexibility to allow collection and management and sorting capabilities for any number of various customer applications. For example, customers may wish to view information for various applications in different formats. One customer may take information relating to tracking of a particular assembly through a manufacturing facility, while another customer may wish to track temperature information at a food storage or retail facility. Each of the various telemetry applications might require different telemetry fields for display purposes. The data manager 160 is provided to allow easy reprogramming, as is well understood in the industry, to facilitate these individual customer differences. As such, various graphical user interfaces (GUI) are provided by data manager 160 according to the particular information being gathered. The GUI interfaces are discussed in more detail in connection with Figures 3A-3E.

Any of various common database management systems can be used by data manager 160. For example, the data manager 160 may be configured to internally organize information in a relational, hierarchical, network or flat scheme, as understood in the art. Likewise, any number of information query extraction protocols may be used. According, to an embodiment, a structured query language (SQL) protocol is employed, for example Microsoft SQL.

Preferably various customer locations communicate with the system over a wide area network, such as the Internet 110. According to our embodiment, the common communication protocol TCP/IP is used for communications over communication lines 108, 118, 116, 114 and 112 and 158. Thus, according to the exemplary system illustrated in Figure 1B, customer A 102 can view information gathered at customer A locations 120 and 122 by logging onto the Internet 110 over communication line 108. Telemetry data is transmitted over communication lines 118

and 116 for the customer A locations 120 and 122 respectively. Data manager 160 is provided the customer telemetry data over communication line 158. Customer A can then access the data by logging onto the Internet 110 over communication line 108 and accessing the Internet web site associated with the data manager 160. Likewise customer B 152, locally at customer B location 124, is given access to the information gathered at the customer B location 124 over communication lines 112 to the data manager 160. Sensor data is transmitted from the customer B location 124 over communication line 114 to the Internet service provider 110 and passed on to the data manager 160 over communication line 158. Typically, customer access to the Internet 110 is provided through common Internet service providers (ISPs) (not shown), although such configuration is not necessary to implement the disclosed subject matter. Another embodiment can provide sensor data directly to the local computer 154 from the reader device 148. Although sensor data can be transmitted in any number of communication protocols within the TCP/IP standard, the specific data protocol according to an embodiment is discussed in greater detail in connection with Figure 2.

Turning now to the data collection configurations at the various customer locations, the disclosed system provides maximum capability for any number of particular system configurations. For example, a large number of sensor systems can be contained with any given customer location. Thus, at customer A location 120 three distinct sensor groups 134, 136 and 138 are used, for example, to obtain temperature information at a food storage or retail facility. At each location a communication bridge 126, 140 and 146 receives information from any number of local data readers. The data readers 132, 130, 128, 142, 148 receive data from the various sensor system groups. According to an embodiment, multiple data readers are preferred where a large number of sensors are present or where sensor location is remote compared to other sensor locations such that substantial interference impedes sensor data transmissions. Multiple readers can also be used where the amount of data exceeds the data reader capabilities.

It should be understood that data reader can be configured or designed to provide increased capacity for an increased number of sensors. Thus, at customer A location 120 where a large number of sensors are used 134, 136, and 138, three data readers are 128, 130 and 132 are utilized. However, at customer A location 122 and customer B location 124, only one data reader 142 and 148, respectively, is necessary to provide effective transmission of sensor data received from sensor groups 144 and 150. Bridge devices 126, 140 and 146 then subsequently receive the sensor information and provide the appropriate interface to transmit the data in TCP/IP transmission protocol over Internet connections 118, 116 and 114. The bridge devices may be of any standard TCP/IP bridge device as is well known in the industry. For example, the

bridge devices may reside inside a local PC, such that a data reader transmits sensor data directly to a local computer. In addition, the reader device may also reside on a local PC, such that sensor data is transmitted directly to the local PC. Typically, only one bridge device is needed per geographic customer location.

The system 100 of Figure 1B is a simplified illustration of one embodiment of the disclosed subject matter. In reality, the system 100 contemplates many more customer accounts at largely nationwide geographic locations. As such, the above discussion ignores the flexibility to manage such a complex system using a single Internet telemetry collection and retrieval interface. However, such addition of customer accounts, accounts within each customer accounts, multiple stage tracking (see Figure 5) and additional tracking locations is provided without more than minor modifications such as additional communication and storage hardware for increased capacity.

Turning now to Figure 2, illustrated is an exemplary transmission protocol according to an embodiment. The example transmission package shown represents data transmitted from the data readers 128, 142, 132, 136 and 148 to the bridge devices 126, 140 and 146 and over the Internet communication links 118, 116, 112 and 158. Data from the readers transmitted to the bridge devices and then over the Internet communication links is a 21 byte ASCII packet, which describes a message from the RF transmitter tag, or sensor. Essentially, the data is continuously transmitted and the packets are received in sets of two or more, separated by a time interval of approximately 32 milliseconds, plus RF data transmission time. Because the RF sensors use an R/C oscillator for its microprocessor clock and can vary from unit to unit, the time window for any program screening these messages or putting them back into sequence should allow for time variations in the expected arrival time of each message. In this way, data is transmitted on a near real time basis to the data manager 160. As such, customers can view data associated with each account on a near real time basis.

According to the communication protocol of an embodiment, the message packets are of one of the following types: V packet, T packet, S packet, X packet and/or X packets. The V packet is a check sum of the data packet if used and of the serial number. A T packet is a data packet sent by the RF transmitter tags or sensors. As discussed, the data packet may be of any type of sensor data, such as temperature, humidity, location or other. The data manager 160 is able to recognize type of data sent and then typically utilizes a look up table to convert values into proper format. For example, a program at the data manager 160 uses the received data to look up temperature (or humidity) from a look up table. The use of the look up table allows the

data to be read in any format required, or convert to another measuring system, such as from Fahrenheit to Centigrade.

It should be noted that any number of communication protocols can be developed and utilized by the system 100 with only minor modifications to the communication software at the telemetry data reader stage. Associated modifications can also easily be made to the software at the data manager to recognize the different protocol. For example, the system 100 may be configured to receive and transmit information on a accelerated basis, thereby enhancing the real time nature of the monitoring capability. In addition, the system may be configured to communicate only basic on/off, hot/cold or presence/absence type information, potentially for cost savings to the requesting customer due to reduced storage requirements.

The S packet type transmits the serial number for the transmitting sensor. The serial number is unique for each sensor which allows unique identification of the data received. In this way, the data manager 160 is able to identify the source of the data for any number of purposes, for example, to alert facilities management personnel of a potential out of range temperature situation at the food storage or retail facility and the location of the affected food parcel vis-a-vis the sensor location. The transmission protocol utilized by the wireless sensors of the sensor array 50 allows for unique identification of each sensor independent of the number of sensors in the sensor array 50 or the system as a whole. As the data is received, the sensor location is then determined from the sensor identification in any number of well known manners, for example a customer maintained predefined look up table. A sensor transmission protocol is more fully described in U.S. Patent Application No. 09/027,968, entitled LOCATION, IDENTIFICATION AND TELEMETRY SYSTEM USING STROBED SIGNALS AT PREDEFINED INTERVALS, previously incorporated by reference. Specifically, a strobed transmission protocol is utilized, according to an embodiment, to transmit the data and sensor identification from the sensors 50. The strobe transmission is flexible for either spread spectrum modulation or narrow band modulation. In addition, the strobe transmission is media indifferent, for example, over infrared or radio frequency (RF).

The X packet is a time mark and is also utilized to send verification that the receiver is functioning in the absence of a received signal. The X packets are noise packets and contain data defining the type of noise received. The noise packets are used for special projects requiring noise data and for preliminary surveys of sites. The noise packets can be used to adjust receiver sensitivity in noisy environments for example. The noise packets can also be used to determine the optimum number of readers necessary for a given number of sensors or to determine the optimum location of the readers for a specified coverage area.

Turning specifically to the messages shown in Figure 2, exemplary meanings for some of the characters in received message are given. Beginning with the sequence character on the left of the chart of Figure 2, each message increments this character from decimal 33 to decimal 128 to identify the packet transmission sequence. The next character indicates the particular package type (V, T, S, !., X), discussed above. Bits [4:7] represent the receiver serial number hexadecimal format. Bits [8:13] represent the receiver time stamp and, represent according to one embodiment 69.444 microsecond increments of time in hexadecimal. Continuing to bit [14], this bit indicates the number of bits received from the transmitter/sensor, also in hexadecimal. Bits [15:18] are the actual telemetry data received. Each packet represents one nibble, four bits, of the message. Typically, less than 14 bits are used. Bytes 19:20 represent the signal engths of the transmission as received by the receiver. The signals vary from 43h for the very weak signals to 75h for the very strong signals. For sensor data and identification data, an entire message is spread over multiple transmission packets. A complete message is coupled by utilizing the time of arrival of subsequent packets to determine which packets are associated with prior received packets. An entire message is recognized when all of the associated packets have been identified and received.

With the data protocol thus defined, the data manager 160 is able to effectively recognize receipt of individual messages and decode accordingly. The protocol is easily modified to provide for additional features or compatibility requirements which may be necessary to implement other applications, such as different telemetry data types. Such a modification of communication protocol could be easily implemented by merely modifying the software at the data manager 160 and the reader 52. As stated above, the protocol discussed in reference to Figure 2 is only one implementation of providing telemetry data to the data manager. Other variations for similar data communication across the Internet may be incorporated in the described system with only minor programming modifications without departing from the disclosed subject matter.

Although the local computer is discussed in terms of receiving information for exemplary purposes, it should be noted that the disclosed system may be easily reconfigured to additionally allow reverse communications, such as control commands to the remote sensor system location. For example, upon receipt of an out of range operation for a piece of equipment, an operator is able to input a control command to turn the malfunctioning equipment off, for example. Only minor additional hardware and software is required for this dual-directional communication application.

Turning now to Figures 3A-3E, shown are exemplary graphical user interface (GUI) displaying information received from a customer's sensor system. The data manager 160 first decodes and sorts the data received according to customer location or other requested variable sorting protocols. The customer or account data is then provided to a GUI application at the data manager 160 for use over the wide area network or internet or to a GUI application at the customer's local computer.

As mentioned, any number of display formats may be configured based either on design efficiencies, customer requests, specific applications and other situations. Figure 3A illustrates one embodiment providing various statistics of a customer's system. Such a screen may be configured to display the number of received messages and the number of detected received errors. In addition, the number of transmits and transmit errors is similarly tracked. This may be utilized to assist in accounting for the previously discussed financial billing feature based on specific information transfers to the customers. This screen also displays the location of where the system looks, which TCP/IP address, to find the receivers and send the data reports.

The strobes tab and strobe display of Figure 3B displays the actual received telemetry data. As can be seen, each telemetry data point is associated with a uniquely identified sensor. Alternatively, the data may be displayed such that an average data is shown, for example, for a region of a facility whereby data from a number of sensors is combined and averaged to present an overall report. Additionally, the data manager 160 may be configured, either by default or at a customer's request, to set certain threshold values. These threshold values may then be used to trigger certain alerts, such as emergency paging of a store manager, email alerts or merely displayed as an alert in red. For example, sensor identification number 150 and 154 are highlighted because the received temperature data has exceeded a preset threshold. In this instance, for example, a store manager may cross reference these sensor id numbers to a location in the store to send a maintenance crew to investigate or replace the malfunctioning refrigerator, for example. Alternatively, the GUI allows that each sensor be given a name such that its location may be easily identified, for example, "deli cooler B" or "seafood display west".

Turning to Figure 3C, shown is the GUI display for the exceptions tab. Preferably, the exceptions displays the transaction log, error log and outgoing transactions. The transaction log includes any alarm notifications or other communications to a particular customer on a customer-by-customer or account-by-account basis. Thus, the exceptions listings may be used to track a customers' use of the system and thereby provide for accurate billing based on that use. Additionally, the exceptions listing provides a historical collection of important system operation events, such as malfunctioning or out-of-range operation. This historical listing can then be

further used to support any accountability of liability based on specific malfunctioning or improper operation. In addition, the exceptions log may be configured to display information such as translation files that are loaded into the system as well as certain communication ports which are maintained by system communication protocol, discussed above. For example, these translation files include tables to allow for translation from the communication protocol discussed in connection with Figure 2 into predetermined units such as Fahrenheit or Celsius. In addition, these translation tables are used, as discussed above, for the various applications in which sensors provide data, such as providing relative humidity and cold drafts measurements. In addition, a translation file can be displayed which is configured to trigger certain notification activity to a customer or an account. Specifically, predetermined thresholds may be configured and stored in an appropriate translation file.

An additional accounting feature as well as a managerial tool is provided by the users tab of Figure 3D. The users tab preferably displays all of the remote access information and connected user information. For each remote connection the display includes, the IP address, a user description and the number of packets or transmissions that have been communicated to that user. Again, this information may be used to easily track the amount and type of activity on a location-by-location basis. For a single user having multiple locations this screen may also be used to compile the activity of the multiple locations and bill only that single user. Additionally, a manager is provided access to view the number of communications to any given location within that manager's authorized access. Thus, a manager at a headquarters office or at a central store is able to view the activity of its multiple accounts, for example to the various multiple stores within that manager's responsible region. Of course, the name field is easily programmed to identify various locations of any given IP address. Similarly, a manager may use the receiver tab of Figure 3E to identify the various receivers at the various multiple locations within that manager's regional responsibility. For example, each receiver may represent a store location or even multiple sub-regions within one store location. This receiver tab provides a easy cross-referencing tool which is accessible by any authorized customer.

It should be noted that the disclosed subject matter is useful in a number of sensing environments providing remote access of near real time data. An application mentioned above relates to temperature tracking of specific food parcels. In such an embodiment, sensors placed in close proximity of a food parcel, such as in a transportation crate at an originating point, provide very accurate environmental readings. Cold chain history can be tracked from the sensor and other sensors of other parcels throughout the delivery process. Because of the continuous

transmit nature of the sensors, a factor in complete cold chain history is a sensor's proximity to a reader for transmission to the data manager.

An embodiment of the disclosed subject matter involves coupling the sensor system 10 of Figures 1A and 1B, and the communication protocol of Figure 2, with GPS and satellite transmission technology. As such, in Figure 4, a RF, for example, sensor tag can transmit to a GPS receiver attached to a delivery truck 304 or a railcar 302, for example, in route from an originating point to a destination point. In that instance, the sensor transmits according to its normal protocol, discussed above, to a local reader inside the delivery truck. The reader then transmits the data according to its transmission protocol, also discussed above, to a local GPS transmitter also installed on the delivery truck 304 or railcar 302. Using well known tellite communication capability, the GPS transmitter sends the sensor information directly to a low orbiting satellite (LOS) 308 where the information is received then transmitted back to the data manager 160 (Figures 1A and 1B) and where the data is received and sorted as if the data had been received over the Internet. From there the data is available at any Internet accessible personal computer 314. Additionally, location data from the GPS communication protocol is available. As such, the data manager 160 is configured to receive this additional GPS location data and thus incorporate the same associated with the telemetry data. Although GPS communications provide the added benefit of location information, other transmission modes are available such as RF and cellular transmission.

Further, notifications of adverse conditions can be sent via telephone 310 or pager to identified individuals. In addition, the truck operator 312 can be notified either directly from the local reader or indirectly through the data manager notification system. Because the same components are used to gather the telemetry data, software and transmission protocol remain constant for this transportation system 300. The transmission links for GPS to LOS service and back to the data manager 160 are performed according to well known established transmission protocol, for example, data compression requirements, and are not further or directly addressed in this application.

Thus, a mobile application of the wide area network system 300, in addition to telemetry data, also tracks general location data. The GPS location data is tied to relevant environmental status updates, associated with the reported telemetry data for tracking throughout the mobile distribution stage in, for example, a food delivery process. As such, attribution of failure liability is enhance for mobile applications by providing a failure location in an otherwise difficult tracking stage in the process. Specifically, warning notifications to an operator or manager of a receiving facility will include the failure warning data and the location of the truck en route.

At this point, for example, the truck dispatcher may be notified of the situation allowing the opportunity to either fix the problem, service the mobile refrigeration unit, or abandon the delivery, thereby saving distribution time and costs for delivery of spoiled product. It should be noted that this is merely one illustration of GPS location data use in connection with the associated telemetry data. Many other uses may be incorporated into the tracking function without departing from the disclosed subject matter.

In addition, various aspects of the subject matter disclosed can be combined in a number of ways to complete an entire food safety cold chain tracking system. Such a system is illustrated for exemplary purposes in Figure 5. Generally, the environmental conditions for a given food parcel can be tracked from harvesting or gathering 402 to processing 404, during transportation 306, as described above, at an interim storage facility 408, during final distribution 410 and then to retail supermarkets 412. For each stage in the process, the environmental conditions such as temperature and humidity are tracked using the sensor arrays and reader devices configured to transmit via a dedicated PC 56 or over a GPS device. In all applications, the sensor telemetry information is received and gathered at a central data manager database where access is then securely provided to authorized customers.

The complete system then begins tracking using sensors of the sensor array 50 for example, a temperature sensor, at the farm 402 itself. For example, a dairy farm utilizing the disclosed system includes sensors to monitor temperature at its temporary storage facilities such as a milk tank or egg refrigeration facilities. Prior to processing 404, the harvested or gathered agricultural product, is assigned a batch number at the farm which relates to storage of the food product in any of the monitored storage facilities, thereby associating food products having a common origin, or a shared process stage. The modification to such a farm facility 402 is a simple installation of the system of Figure 1A. Installations resembling that illustrated in Figure 1B are particularly appropriate for institutional farming corporations seeking to track efficiency and product survivability at the initial gathering stage. Such environmental information can then be used also as historical information to protect against certain liability issues arising in the production and distribution of the relevant product. For example, refrigeration failure liability may be apportioned to the party or parties responsible for process operations in which a 'hot' condition occurred.

A similar installation is present at a processing stage or processing plant 404. Here again, the particular food parcel to be monitored is assigned a batch number and tracked back to its produced batch number, all of which is assigned to the storage facilities utilized and other monitored processes. In this way, a particular food parcel is tracked using the identification

feature of the sensors of the sensor array. Specifically, historical data can be determined over a period of time after the processing step 404 merely by cross-referencing the historical data of a particular sensor as assigned to a particular batch of food parcel. Likewise, food products having a common origin, for example, a particular day of output at a dairy plant, may be associated across the various processing and delivery stages and tracked accordingly. Additionally, as with the other installation applications, the processing plant manager can utilize the remote monitoring to track the operation of refrigeration facilities at the various other processing sites.

Additionally, other processing environmental tracking configurations can be utilized. For example, multiple sensors can be used in tandem along with software modifications to determine cold airflow draft at certain points during the processing operation. Differential measurements from sensors are received through the reader device and then processed by local software at either a modified reader or at a PC located at the customer site. Additionally, a sensor can be embedded in a food simulator to provide wireless tracking of the simulator through the entire actual process path. Here again, one or multiple readers can be used at various locations in the processing plant 304 to receive the wireless telemetry data. An accurate tracking picture is provided as the food simulator is designed to most closely approximate the actual characteristics, such as specific heat value and mass, of a typical food product through the processing operation. Here again, the wireless data is received and transmitted in the manner described in connection with Figures 1 and 2.

Similar tracking techniques can be applied to multi-systems energy consumption monitoring. For example, remote sensors can be configured to sense power surges or current differential at a primary power line input into, for example, a location with multiple refrigeration units, such as a supermarket. Received data can be correlated by time stamp with known refrigeration operation to detect potentially defective functionality. Here again, the wide area network provides a convenient and accurate monitoring for a multiple location customer system with configurated automatic notification.

Continuing with Figure 5, the environmental tracking for the transportation 406 and distribution 410 phases is achieved using a similar configuration described in connection with Figure 4. Here the GPS satellite connection is incorporated on the delivery vehicle itself to provide near real-time information to the data manager, providing access on a near real-time basis to an authorized customer. The information can then be used to warn a product receiver, such as an operator of the storage facility 408 or an operator of a retail supermarket 412, of any or substantial out of range temperature or other environmental operation. Likewise, as with the

other applications, the environmental telemetry data is then stored in a historical database for later retrieval, for example to track down environmental conditions which may have led to food spoilage.

Finally, following the food parcel to a dedicated storage facility 408 or ultimately to a retail supermarket 412, the installation at these dedicated locations includes the appropriate number of sensors in the sensor array 50 of Figure 1A along with the appropriate reader devices 52. Additionally, bridge devices alone or incorporated into local personal computers 56 are provided for onsite monitoring of the gathered environmental telemetry data. Here again, the configuration of Figure 1B is particularly applicable to a supermarket chain store where supermarket management wishes to achieve efficiencies by creating tracking benchmarks for certain employee tasks. In addition, the system can effectively be used as in other applications described herein, to monitor third party supplied equipment, such as refrigeration units thereby providing further liability apportionment to the actual refrigeration unit suppliers.

Thus, according to the disclosed subject matter, a complete system is provided to reliably and accurately track telemetry data sensed at a single or multiple remote locations. Tracking environmental data is provided for mobile applications by combining GPS and satellite communication technology with the single Internet interface. Further, complete telemetry tracking is provided across every stage in a multi-stage process, such as a food processing and delivery chain, by associating unique sensor identification with specific parcels in the delivery process. Separation of food parcels is tracked by associating multiple other unique sensor identifications to the subsequent separated delivery parcels.

Attribution of liability is provided through review of historical cold chain data or through real-time monitoring and notification of telemetry data indicated potentially failure or failed environmental maintenance. Additionally, a secured access protocol is provided whereby only authorized customers receive notifications or are given access to the real time data. A multiple level security protocol can be configured within each customer account, for example on a location by location basis. Finally, accurate financial billing is provided to each customer by virtue of the tracking capabilities of the system. Billing is selectably established to multiple participants in the multi-stage process based on that customer's involvement in the process or by other agreement between the parties.

The foregoing disclosure and description of the various embodiments are illustrative and explanatory thereof, and various changes in the descriptions of the hardware configuration, of the communications protocols, of the organization of the components, and the order and timing

of steps taken, as well as in the details of the illustrated system may be made without departing from the spirit of the invention.

CLAIMS:

We claim:

1. A distributed wide area network for local monitoring of remote sensor systems, comprising:

a wide area network;

a plurality of remote data readers coupled to the wide are network, the remote data readers adapted to receive telemetry information transmitted from telemetry sensors;

a remote database coupled to the plurality of data readers over the wide area network, the remote data base adapted to receive and maintain the telemetry information from the telemetry sensors; and

a local computer coupled to the remote database via the wide are network wherein the local computer receives telemetry information from the remote database.

2. The system of claim 1, wherein communications over the wide area network follows TCP/IP communication protocol.

3. The system of claim 1, wherein the remote database is distributed across different servers.

4. The system of claim 1, wherein the remote database is comprised of multiple associated remote databases.

5. The system of claim 1, wherein accesses to the remote database results in transaction charges or billing to an entity assigned to the local computer initiating the remote database access.

6. The system of claim 1, wherein the remote database is duplicated in a local database on the local computer.

7. The system of claim 6, wherein the remote database and the local database are synchronized when a user initiates a synchronize control command on the local computer.

8. The system of claim 1, wherein the remote database is a real time database for the received telemetry information.

9. The system of claim 1, wherein communication between the remote database and the local computer is initiated by a control command upon a user request at the local computer.

10. The system of claim 1, wherein communication between the remote database and the local computer is initiated on a predetermined periodic basis.

11. The system of claim 1, wherein the local computer receives telemetry information associated with selected telemetry sensors and data readers.

12. The system of claim 11, wherein the selection is based on a customer location or customer account.

13. The system of claim 1, wherein the telemetry sensors are humidity sensors or temperature sensors.

14. The system of claim 1, wherein at lease one remote data readers is installed at a mobile location.

15. The system of claim 14, wherein the mobile location is a food delivery truck.

16. The system of claim 14, wherein the remote data reader installed at the mobile location provides both sensor telemetry information and Global Positioning Satellite (GPS) developed location data to the remote database via a communications link.

17. The system of claim 16, wherein the communications link is a satellite communications link or is a cellular communications link.

18. The system of claim 1, wherein for each customer account the remote database stores the telemetry information, time of the received telemetry information, an identification of the transmitting data reader and an identification of the transmitting telemetry sensor.

19. The system of claim 1, wherein the telemetry information is provided to a paging device.

20. A method for monitoring a plurality of sensor systems at remote locations, comprising the steps of:

transmitting from a reader device to a wide area network telemetry data from a sensor system;

receiving in a central database over the wide area network the telemetry data transmitted from the remote locations;

transmitting the telemetry data from the central database to a local database.

21. The method of claim 20, further comprising the steps of:

receiving in the reader device at a remote location telemetry data from a plurality of sensors;

uniquely identifying the sensor from which data is being received; and

transmitting the sensor identification with the telemetry data.

22. The method of claim 20, further comprising the steps of:

tracking transactions with the local database; and

billing a customer financial account based on the number or time of transactions.

23. The method of claim 20, wherein the telemetry data is transmitted to the reader device using wireless communication techniques.

24. The method of claim 20, wherein the central database is accessible only by authorized users.

25. The method of claim 20, wherein transmission over the wide area network follows TCP/IP communication protocol.

26. The method of claim 20, wherein portions of central database is replicated in the local database.

27. The method of claim 20, wherein the local database is updated with telemetry data from the central database upon a user request.

28. The method of claim 20, wherein local database is updated with telemetry data from the central database on a predetermined periodic basis.

29. The method of claim 20, wherein the central database is distributed across different servers.

30. The method of claim 20, wherein the central database is comprised of multiple associated central databases.

31. The method of claim 20, wherein the central database provides the received telemetry data in real time.

32. The method of claim 20, wherein the local database receives telemetry data associated with selected telemetry sensors and data readers.

33. The method of claim 32, wherein the selection is based on a customer location or customer account.

34. The method of claim 20, wherein the telemetry sensors are humidity sensors or temperature sensors.

35. The method of claim 20, wherein at lease one remote data reader is installed at a mobile location.

36. The method of claim 35, wherein the mobile location is a food delivery truck.

37. The method of claim 20, wherein the remote data reader installed at the mobile location provides both sensor telemetry data and Global Positioning Satellite (GPS) developed location data to the central database via a communications link.

38. The method of claim 37, wherein the communications link is a satellite communications link or is a cellular communications link.

39. The method of claim 20, wherein for each customer account the central database stores the telemetry information, time of the received telemetry information, an identification of the transmitting data reader and an identification of the transmitting telemetry sensor.

40. The method of claim 20, wherein the telemetry data is provided to a paging device.

41. An internet based wide area network sensing service system for providing local monitoring and controlling of remote sensor systems, comprising:

a client computer coupled to the internet;

a host server coupled to the internet computer for communicating with the client computer over the internet connection; and

a central database coupled to the host server providing access to stored information to the client computer and providing financial billing information based on access requests;

a plurality of remote sensors systems, each system comprising:

a plurality of sensors;

a reader device at the remote location for receiving data from the plurality of sensors; and

a bridge device coupled to the reader device for transmitting sensor data to the host server and for receiving control commands from the client computer.

42. A system for managing access to multiple locations of sensor systems over the internet comprising:

a first sensor system associated with a first customer, including:

a first internet server coupled to the internet; and

at least one reader coupled to the first internet server, the reader receiving telemetry data from a first plurality of wireless transmitters in the vicinity of the reader;

a second sensor system associated with a second customer, including:

a second internet server coupled to the internet; and

at least one reader coupled to the second internet server, the reader receiving telemetry data from a second plurality of wireless transmitters in the vicinity of the reader;

a data management server on the Internet securely accessing the first internet server and the second internet server and rendering a database of telemetry data associated with each transmitter.

a first customer computer coupled to the Internet, the data management server securely providing data associated with the transmitters at said first customer location to the first customer computer and providing financial billing based on data provided to the first customer;

a second customer computer coupled to the Internet, the data management server securely providing data associated with the transmitters at said second customer location to the second customer computer and providing financial billing based on data provided to the second customer;

wherein the data management server restricts each customer's ability to access data other than that customer's own data.

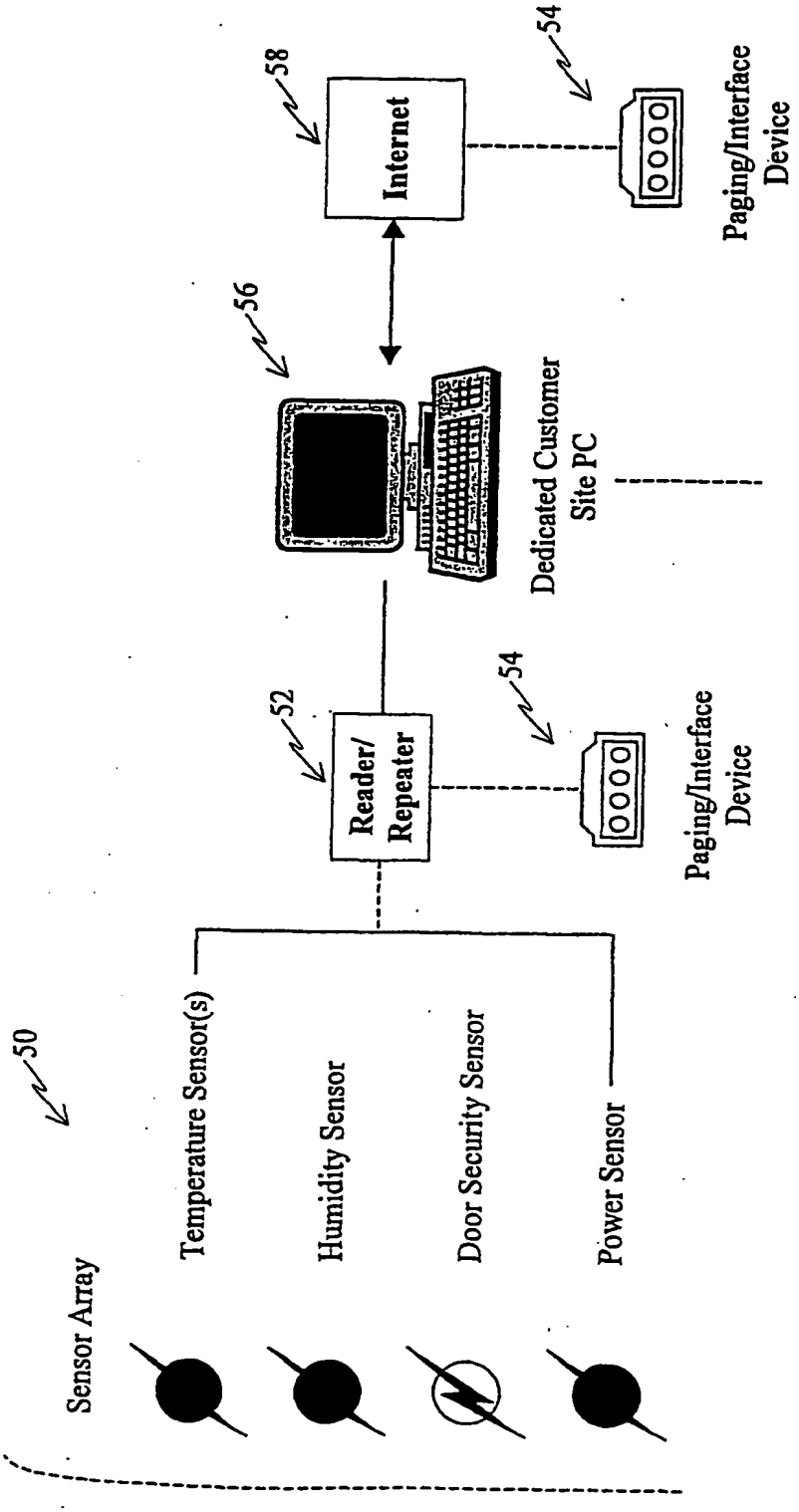
10
PC/Internet Connection
58
Internet
54
Paging/Interface Device
56
Dedicated Customer Site PC
52
Reader/ Repeater
54
Paging/Interface Device
50
Sensor Array
Temperature Sensor(s)
Humidity Sensor
Door Security Sensor
Power Sensor

Figure 1A

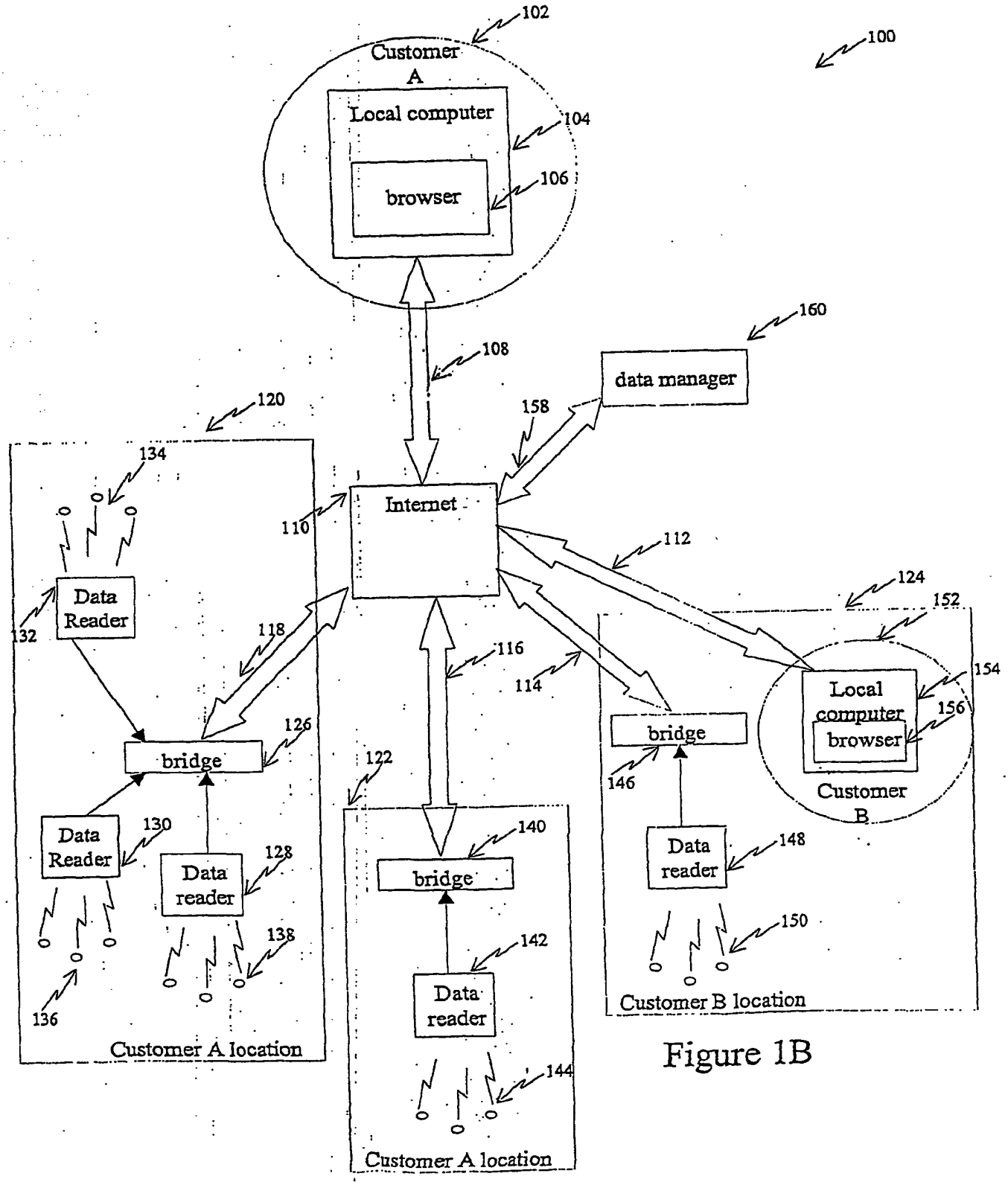
102
Customer A
Local computer
104
browser
106
100
108
160
data manager
158
120
134
Internet
110
112
124
152
Data Reader
132
118
116
114
154
Local computer
browser
156
126
bridge
bridge
146
122
130
Data Reader
128
Data reader
140
bridge
148
Data reader
142
Data reader
150
138
136
144
Customer A location
Customer B
Customer B location
Customer A location

Figure 1B

seq. char	msg. type	serial #	time stap	bits revol.	data	signal strength	message content
8	V	017B	14EE16	G	11C7	60	3rd character indicates that this is a verification packet
9	T	017B	14F024	G	0432	61	3rd character indicates that this is a data packet
:	S	017B	14F231	E	0207	60	This is a serial number byte 2 -07 - second byte is 07hex
;	S	017B	14F438	E	0135	60	This is a serial number byte 1 -35 - least sig. Byte 35hex
<	!	017B	150000	0	0000	00	Time mark shows up approximately every 32 seconds.
=	x	017B	15D4D6	E	0102	3E	Noise packet indicating type 1 noise.
>	V	017B	1A12D7	G	11C7	61	
?	T	017B	1A14E5	G	0432	62	The 62 indicates a very strong signal received
@	S	017B	1A16F2	E	0207	60	
A	S	017B	1A18F9	E	0135	60	
B	!	017B	1C0000	0	0000	00	
C	V	017B	1C958C	G	31A9	44	very weak signals indicated by 44 on the end of packet.
D	T	017B	1C979F	G	043A	49	
E	S	017B	1C99B0	E	0207	44	LSB serial number byte was aborted due to bad reception.
F	V	017B	1F37A5	G	25C7	60	1f37a5=2045861 time of first byte arrival
G	T	017B	1F39B4	G	0437	62	1f39b4=2046388 - 2045861 = 527 x 69.444 = 36.5988 ms
H	S	017B	1F3BC1	E	0207	61	1f3bc1=2046913 - 2046388 = 525 x 69.444 = 36.4581 ms.
I	S	017B	1F3DC8	E	0135	60	1f3dc8=2047432 - 2046913 = 519 x 69.444 = 36.041436 ms
K	!	017B	230000	0	0000	00	
L	V	017B	235A88	G	31A9	46	
M	T	017B	235C9B	G	043A	4A	
N	S	017B	235EAC	E	0207	44	
O	S	017B	2360B8	E	0151	45	

FIGURE 2

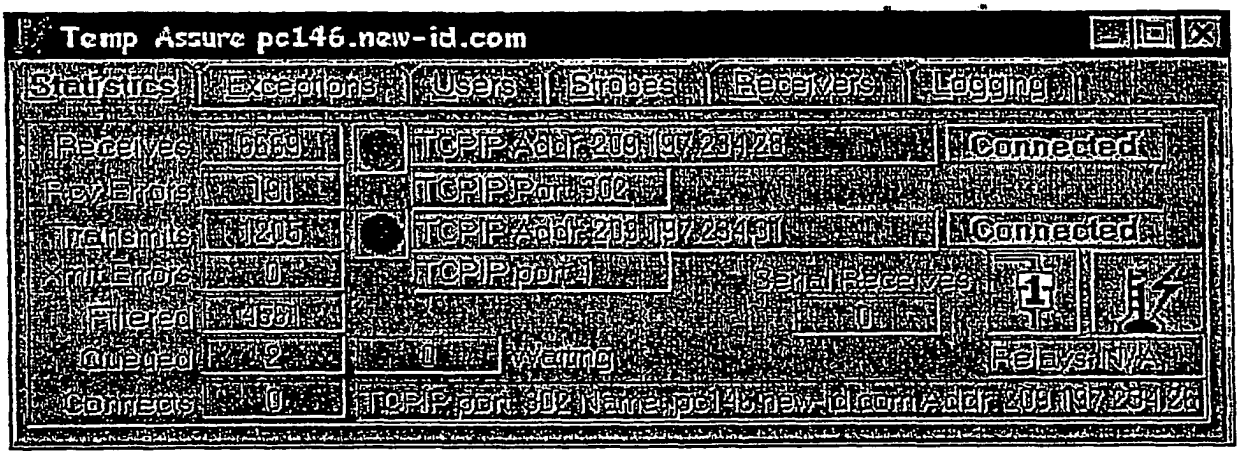

Figure 3A

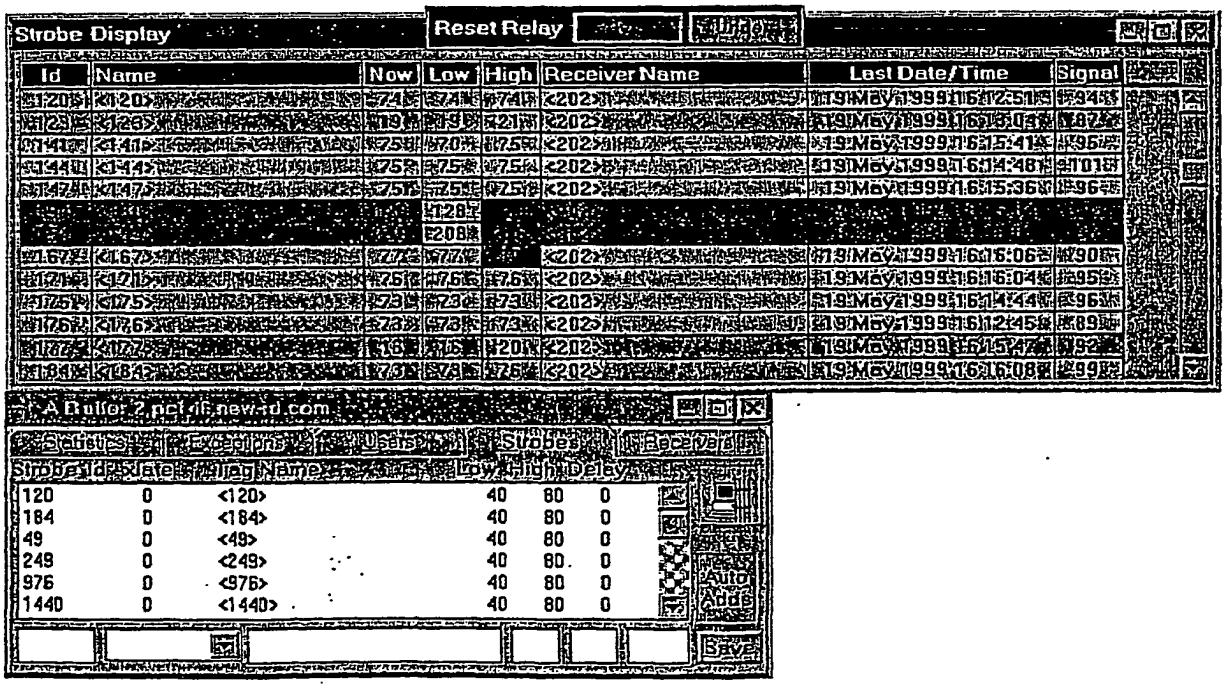

Figure 3B

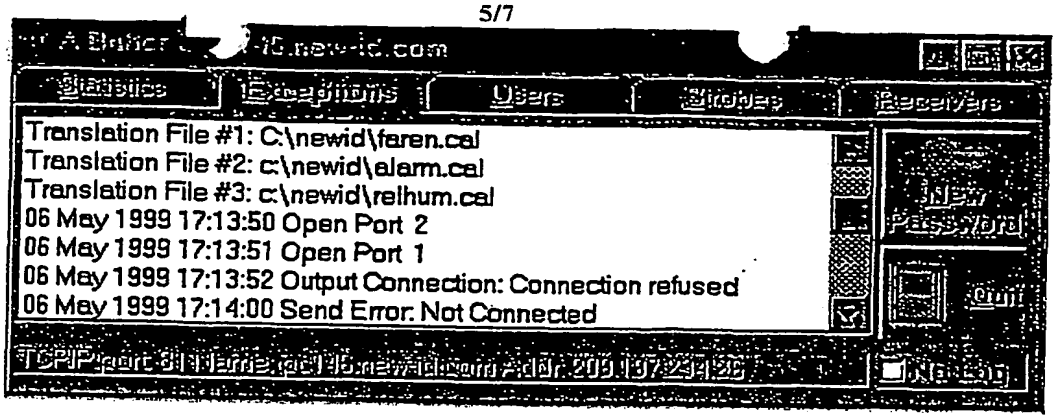

Figure 3C

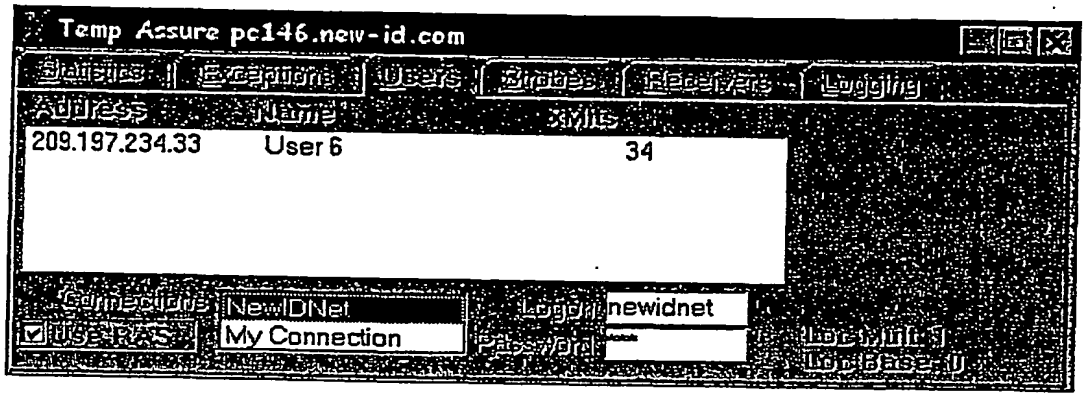

Figure 3D

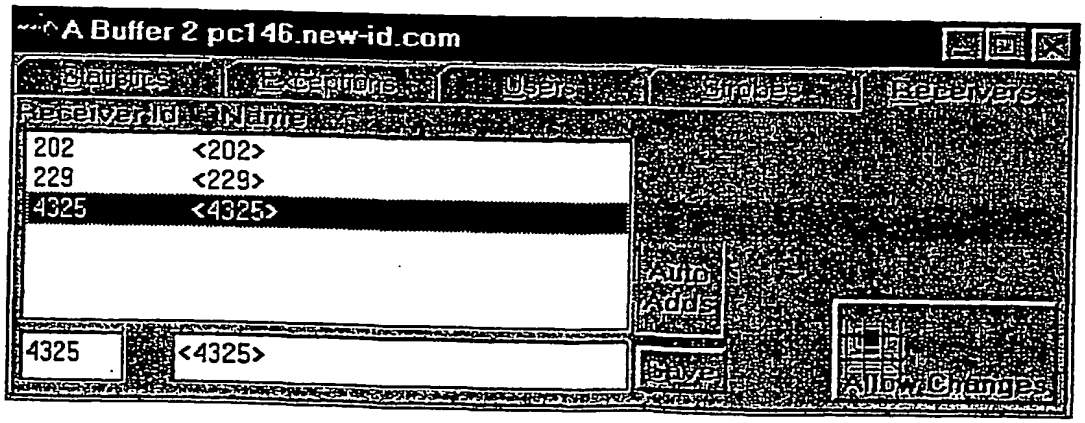

Figure 3E

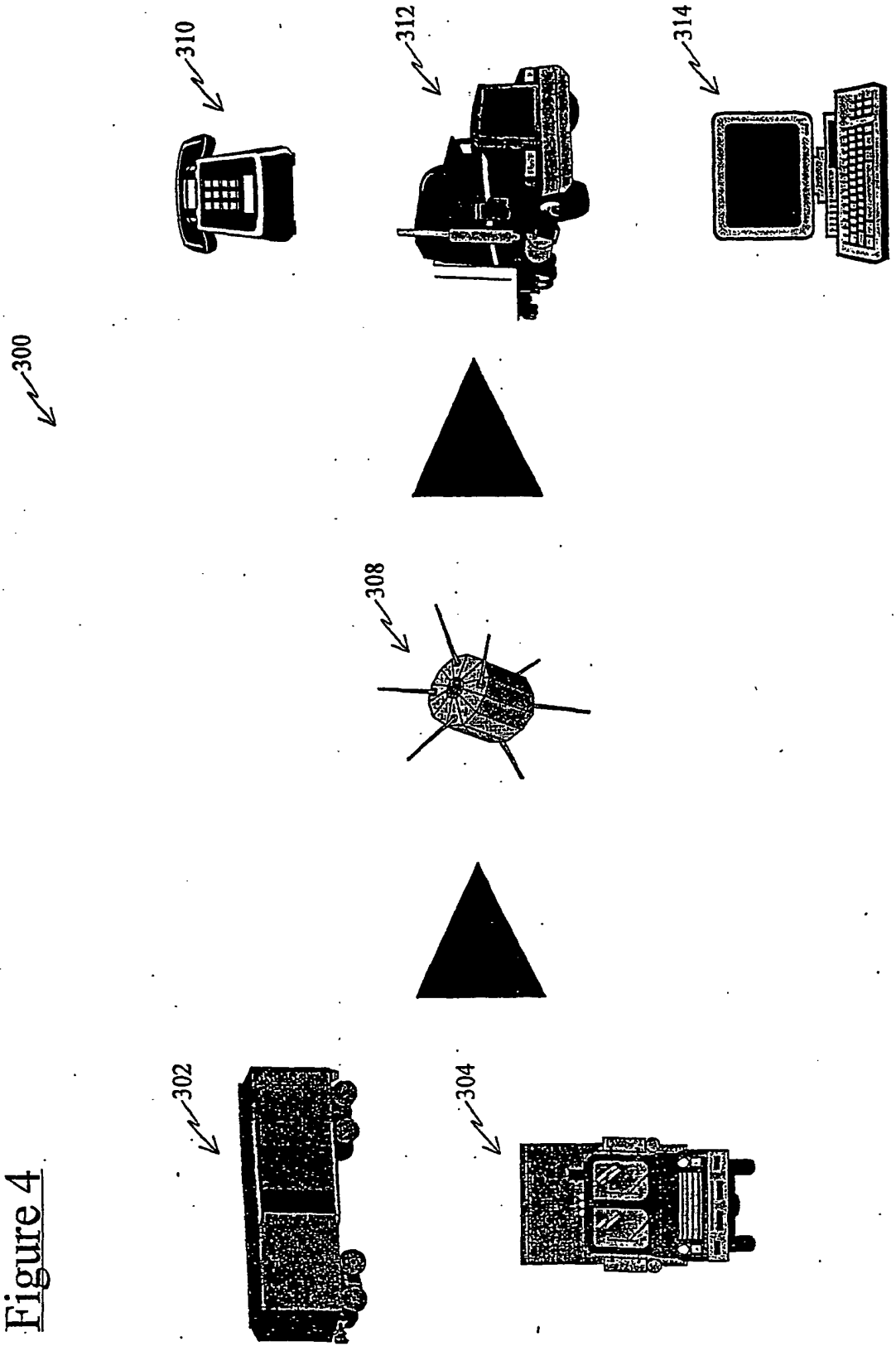

Figure 4

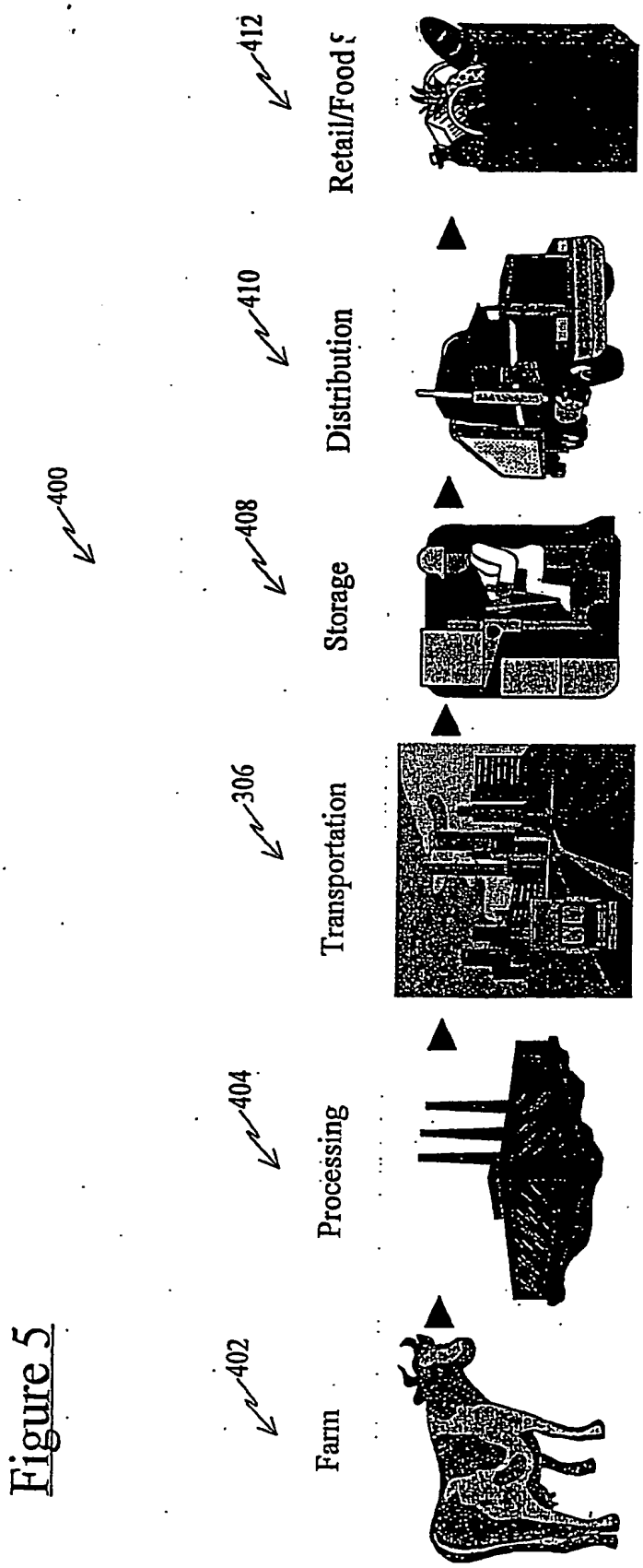
400
402
Farm
404
Processing
306
Transportation
408
Storage
410
Distribution
412
Retail/Food

Figure 5

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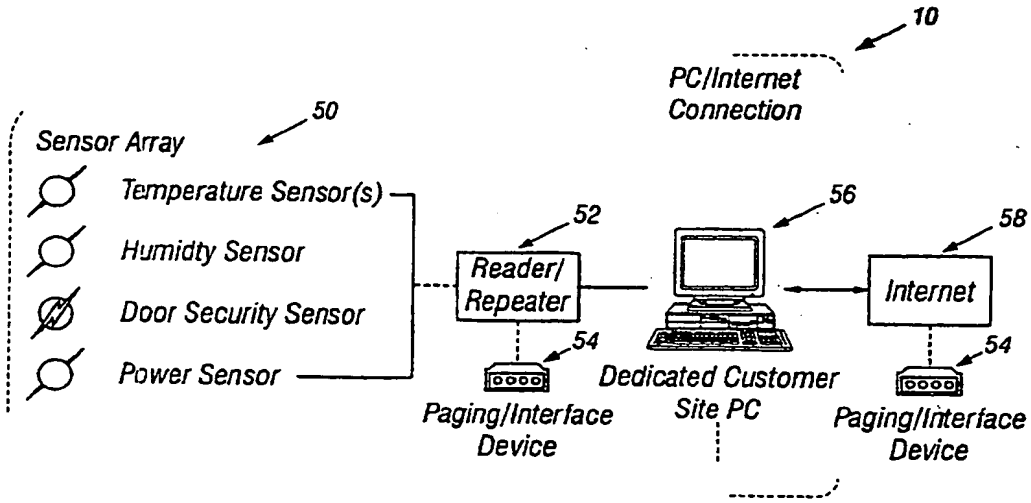
(54) Title: WIDE AREA NETWORK BASED OBJECT SENSOR SYSTEM



(57) Abstract: A wide area computer network provides monitoring of multiple sensor systems located at remote locations. Specifically, a telemetry data from sensors at various locations is received at a central database which is accessible via the Internet by local personal computers. A store manager is thus able to display in real time at a distant location the temperature status of various refrigeration units located at various stores. The central database provides access to customer data only to authorized users. In this way, a single internet interface is provided to receive and manage data from multiple customer accounts over a common system. Further, the system provides separate accurate financial billings to customers based on number or times of access or other customer specified arrangements. In addition, the central database is flexible to receive data from various installations including from dedicated sites or from mobile locations. In this way, telemetry data may be tracked and displayed throughout a multi-stage process involving multiple parties. Alert notifications may be sent to any authorized person in the process chain of out of limit operation.

WO 01/97556 A3

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IN RNATIONAL SEARCH REPORT

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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

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X	WO 99 45761 A (CURKENDALL LELAND D ;PAPE WILLIAM R (US)) 16 September 1999 (1999-09-16) page 12, line 5 -page 13, line 24 page 16, line 6 -page 19, line 20 page 32, line 5 -page 37, line 5 --- -/--	1-4,6,8, 9,11-13, 20,21, 23-27, 29-34 41,42

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Date of the actual completion of the international search	Date of mailing of the international search report
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Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	column 5, line 13 -column 6, line 44 column 8, line 20 -column 10, line 37 column 11, line 58 - line 65 column 13, line 12 -column 14, line 27 column 23, line 58 -column 24, line 14 column 33, line 22 -column 36, line 39	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 01/40986

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		US 5904727 A	18-05-1999

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